Brief Insight about long-term sequelae of pelvic fracture urethral injury Repair and their Management

Mohamed Shawkey Mahmoud El-Desoukey, Aref Mohamed Marouf, Mohamed Mahmoud Seleem, Ahmed Mohamed Eliwa
Urology Department, Faculty of Medicine - Zagazig University, Egypt
Corresponding author: Mohamed Shawkey Mahmoud El-Desoukey
E-mail: mohcoldzero11@gmail.com
Conflict of interest: None declared.
Funding: No funding sources.

Abstract

Pelvic fracture urethral injuries (PFUI) represent a significant urological challenge, often resulting in long-term functional sequelae that significantly impact patients' quality of life. Effective management necessitates a multidisciplinary approach encompassing immediate stabilization, meticulous surgical repair, and comprehensive long-term follow-up. Immediate management focuses on haemodynamic stabilization and preventing further urethral injury. This often involves suprapubic catheterization to divert urine and allow for delayed definitive urethral reconstruction. The timing and technique of surgical repair remain controversial, with factors such as injury severity, patient comorbidities, and surgeon expertise influencing the choice between primary or delayed reconstruction. Options include primary anastomosis, buccal mucosal graft urethroplasty, and various flap techniques, each with specific indications and potential complications. Pelvic fracture (PF), while infrequent, presents a significant urological challenge, with pelvic fracture urethral injury (PFUI) occurring in 1.6% to 25% of cases. Initial assessment necessitates a comprehensive history and imaging, including immediate cystourethrography, with potential for repeat imaging and MRI later to guide management. Preoperative imaging (cystourethrography and MRI) can predict the complexity of delayed urethroplasty, which is the gold standard treatment, usually performed at least 3 months post-injury after stabilization of other injuries. In men, this typically involves a bulbo-prostatic anastomosis; corpora splitting, partial inferior pubectomy, and in rare cases, total pubectomy or urethral rerouting, may be necessary to achieve a tension-free repair. Complex PFUI cases (e.g., significant urethral gap, bulbar necrosis, failed endoscopic realignment, pubic symphysis hardware, pediatric PFUI, previous urethroplasty failure, concomitant anterior urethral stricture, or recto-urethral fistula) warrant referral to experienced centers. Surgical reconstruction achieves urethral patency in approximately 86% of cases. Postoperative evaluation should proactively address potential complications, including erectile dysfunction and urinary incontinence, to optimize patient outcomes.

Keywords: long-term sequelae, pelvic fracture urethral injuries

Tob Regul Sci. ™ 2023 ;9(1): 8831-8842
DOI : doi.org/10.18001/TRS.9.1.627

Introduction

Pelvic fracture (PF) is a uncommon emergency which represents about 10% of blunt trauma and is associated with a male to female ratio that varies depending on the age, with injury prevalence being reported higher in males for young adults and higher in female over 50 years of age [1], [2], [3]. PF resulting in pelvic fracture urethral injury (PFUI) are usually caused by a high-impact mechanism; motor vehicle collision being one of the most frequent causes of PFUI, acknowledging geographic variation in mechanisms [4], [5]. PFUI finally occurs in 1.6% to 25% of PF [6], the risk of urethral injury being higher in cases of pubic rami fractures alone or associated with sacroiliac joint diastasis, Malgaigne's fracture (2 ipsilateral vertically oriented pelvic ring fractures, anterior and posterior to the acetabulum), displaced fractures of the inferomedial pubic bone, or symphysis pubis diastasis [7], [8]. PFUI is the most common urological injury associated with PF and can lead to long-term urethral stenosis. The high-impact mechanism causing PFUI often also results in other functional sequelae, including erectile dysfunction and urinary incontinence. Management of those long-term sequelae raises several questions not always answered by the limited literature available [6]. This paper will examine long-term management of PFUI by focusing on urethral injury assessment, urethral stenosis treatment, and other sequelae associated with urethral injury.

2. Urethral injury assessment

2.1. Initial injury history

Analysis of the initial injury history and its acute management are fundamental for planning the long-term management of PFUI, and special attention must be given to the type of fracture, the anticipated approach to repair of the anterior pelvic ring fractures (notably use of osteosynthesis material on the superior pubic ramus), or the presence of associated vaginal or rectal injuries.

Although acute injury management is beyond the scope of this review, classification of the urethral injury must be determined. The American Association for the Surgery of Trauma (AAST) and the European Association of Urology (EAU) have each provided grading systems, both based on retrograde urethrography findings [9], [10]. Despite some differences (inversion of grade 1 and 2, and characteristics for complete disruption grading), the idea of distinguishing partial disruption (bladder or proximal urethra filled with contrast) and complete disruption (no visualization of proximal urethra or bladder) are important as they result in different prognosis: partial disruption may result in 50% of cases in urethral obstruction and need for urethroplasty, whereas complete disruption injuries are associated with a much higher risk [11].

PFUI was initially considered a membranous urethral injury, at the point fixed by the urogenital diaphragm [6]. This belief was refuted by a cadaveric study that showed that the urethra is tightly adherent to the pubic bone and less adherent distal to the sphincter, resulting in disruption located more distally towards the bulbar urethra [12]. Other urodynamics and imaging studies [13], [14] have confirmed that in the majority of cases, PFUI is a bulbo-membranous injury, occurring distal to the striated sphincter.

Finally, early management of the urethral injury must be examined in the context of later stricture development. In the absence of definitive evidence of the benefit of early endoscopic realignment [15], [16], supra-pubic tube placement is generally preferred as initial management when urethral catheterization is not easily feasible during a simple retrograde cystoscopy [15], [17]. A previous failed realignment may result in more complex urethroplasty [18], similarly to the reported complexity increase of urethral strictures associated with transurethral treatments [19].
2.2. Imaging

The initial gold standard diagnostic method for PFUI is a combined retrograde urethrography (RUG) and voiding cystourethrography (VCUG). Initially, it allows the assessment of urethral injury grade, the bladder neck competence (open or closed) and the presence of other preexisting bladder pathology (diminished capacity, reflux, diverticulum) [13]. This imaging could nevertheless over-diagnose complete disruption of the urethra as some patients may present a concomitant sphincter spasm that prevent passage of contrast (Fig. 1). The use of tamsulosin has been suggested as a possible additional tool to VCUG to help bladder neck opening and improve the diagnostic accuracy of this study [5]. Urethral gap length and gapometry/urethrometry index measured on combined RUG-VCUG has also been reported as a predictor of the need for an elaborated perineal approach to urethral reconstruction [20]. Antegrade flexible cystoscopy is a reliable means to assess the bladder neck and patency of the prostatic urethra if not visualized on urethrography.

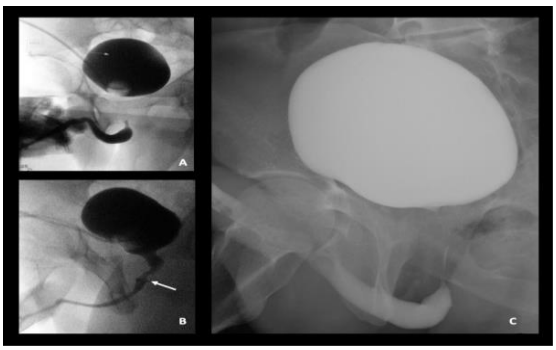

Fig. 1. Pre- and postoperative cystourethrography. A. Preoperative reconstruction from both retrograde urethrography and cystography, showing complete disruption without opacification of the prostatic urethra due to sphincter closure (patient 1). B. Postoperative cystourethrography, white arrow indicating anastomosis site (patient 1). C. Preoperative retrograde cystourethrography showing partial disruption (patient 2).

Even if not playing a role in staging the long-term urethral injury, the initial abdomen-pelvis CT performed in the acute settings may help to determine the PFUI history. Signs of elevation of the prostatic apex, as well as contrast extravasation above and below the urogenital diaphragm, are indicative of higher-grade urethral injury [21].

MRI currently has no role in the acute setting, but it can be a useful tool for long-term PFUI assessment. It can evaluate the length of urethral stenosis or defect [22], the prostate position and its eventual displacement, and the extent of scar tissue. It is the preferred examination to evaluate periurethral structures and is key in cases of urethral fistula, rectal injury, or cavity formation [23]. The prognostic value of specific MRI findings has also been evaluated. A lower pubo-urethral stump angle has been reported as an independent predictor of the need for an elaborated urethroplasty define by the need for inferior pubectomy or urethral rerouting [24]. Also, a shorter membranous urethral length has been reported as an independent predictor of urinary incontinence after urethroplasty for PFUI [25]. Finally, MRI urethrography using tamsulosin allows 3D urethral reconstruction and may be effective for advanced preoperative planning [26].

3. Urethral stenosis treatment

3.1. Timing

SPT placement is generally preferred during acute management of PFUI. Prolongation of SPT drainage could nevertheless impact decision regarding the management of the concurrent pelvic fracture and rarely preclude open reduction and internal fixation [27]. There is a lack of evidence regarding a greater risk of infection associated with SPT in cases of pelvic fracture fixation [6], but there remains discordance between urologists and orthopedists as to opinions about optimal management [28]. Interdisciplinary dialogue remains critical to determine urethroplasty timing and optimize patient outcomes. It is crucial to ensure the full and effective healing of bony fractures before proceeding to schedule surgery, and to confirm the patient's ability to be comfortably positioned into a moderate or high lithotomy position, emphasizing the importance of optimal conditions for a successful surgical intervention.

The delay before considering urethroplasty must allow for complete resolution of hematoma and advanced local healing. While the possibility of an early urethral repair (3–6 weeks) has been advocated for by some surgeons [29], it is more commonly recommended to wait a minimum of 3 months, with 3–6 months being the most frequent range suggested [6], [17], [30], [31].

3.2. Modalities

AUA and EAU guidelines show agreement that delayed urethroplasty is the treatment of choice for post-traumatic posterior urethral stenosis. Endoscopic treatment must not be performed for an obliterative stenosis and no more than one attempt at endoluminal treatment may be tempted for a short, non-obliterative stenosis [32], [33].

3.3. Bulbo-prostatic anastomotic (BPA) urethroplasty

The gold standard technique for delayed urethroplasty after PFUI is a bulbo-prostatic, tension-free, anastomotic urethroplasty through a perineal approach [34], [35]. The technique consists of dissecting the bulbar urethra from the overlying bulbospongiosus muscle, from the central tendon of the perineum and dorsally from the corpora cavernosa. The urethra is then mobilized distally to the penoscrotal junction, in order to capitalize on its elasticity and gain length to bridge the defect. The bulbar urethra is then transected at the most proximal extent and most often, the bulbourethral arteries need to be transected [13]. The distal urethra then becomes dependent on retrograde vascularization from the dorsal artery of the penis (through perforating arteries or glans vascularization). This may in rare circumstances lead to urethral ischemia causing failure due to anastomotic stricture and even bulbar necrosis. An artery sparing technique, transecting only 1 of the 2 bulbar arteries, has been proposed to avoid this rare complication [36].The proximal part of the urethra and its scarred segment is then located, generally using antegrade passage of a cystoscope or metal sound into the posterior urethra [13]. Scar tissue must be completely excised until the posterior urethral is pink, normal in caliber, and mobile (Fig. 2). Caution during lateral excision is essential to avoid damage to the neurovascular bundles (Fig. 3). A bulbo-prostatic, tension-free, mucosa-mucosa anastomosis is then performed after spatulation of the bulbar urethra [13], [37]. Although many approaches to spatulation have been proposed and summarized recently [37], we favor Kulkarni's recommendation to spatulate the distal urethra dorsally [5], and typically do not spatulate proximally. However, if further visualization or a wider caliber is required proximally, we spatulate dorsally as well.

Fig. 2. Complete excision of scar tissue.

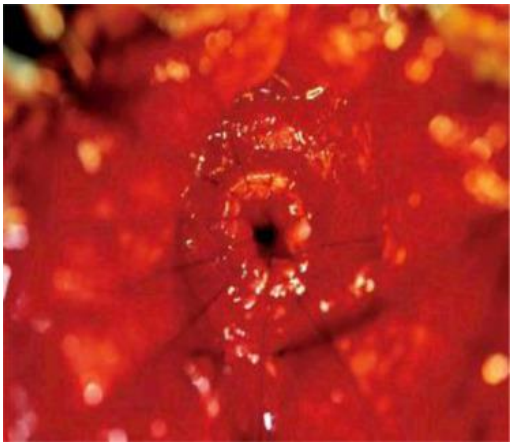

Fig. 3. Pink, mobile, proximal urethral stump.

Several steps of increasing complexity have been described to facilitate tension-free anastomosis [35]. These consist of complete mobilization of the corpus spongiosum to the penoscrotal junction, corporal splitting, partial inferior pubectomy, and possible total pubectomy or urethral rerouting around one corpus cavernosum [13], [35]. The objectives of those techniques are to shorten the length between the two urethral segments. If performed, pubectomy must be wide enough to accommodate one finger, and can be done mechanically (rongeur or gouge) or using an orthopedic drill [38]. Urethral rerouting is less frequently needed but still represents a surgical option in PFUI management, although it must not be considered in case of poor blood supply to the bulbar urethra (bulbar necrosis) and in those cases other types of reconstruction (flaps, entero-urethroplasty) must be considered [39].

3.4. Complex cases

Increasing complexity of PFUI repair may be encountered in the presence of a long gap between the two urethral segments, bulbar necrosis, orthopedic material in symphyseal region (Fig. 4), false passage after failed endoscopic realignment (Fig. 5), pediatric PFUI [40], failed previous urethroplasty, associated anterior urethral stricture, or recto-urethral fistula.

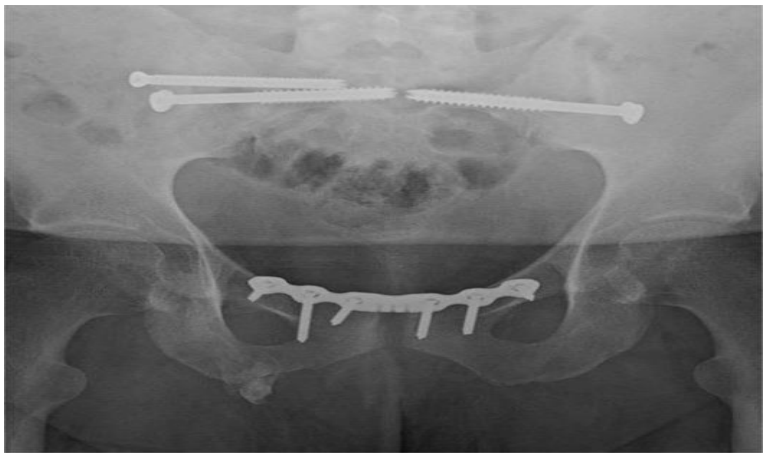

Fig. 4. Orthopedic material interfering with PFUI repair.

Fig. 5. False passage after failed endoscopic realignment.

Those cases should be managed in expert centers. Surgical techniques in the armamentarium include increasing the depth of the inferior pubectomy up to 80%; trans-pubic approach to further shorten the distance between proximal and distal ends; or by using alternative techniques of urethral reconstruction such as tubularized preputial flap, entero-urethroplasty, or other cutaneous flaps [41].

3.5. Outcomes

In the series reporting BPA urethroplasty, success is typically characterized by the absence of recurrence during follow-up; according to the AUA guidelines, the most conclusive confirmation of stricture recurrence is often achieved through the utilization of urethrocystoscopy, urethral ultrasound, or a combination thereof [33].

Overall, success rate is about 86%, for a varying length of follow-up, which is sometimes of several years [6]. Recurrence may occur in case of technical failure (tension on the anastomosis, failure to remove sufficient scar, or inadvertent anastomosis of urethra to the anterior prostate or bladder wall) or bulbar ischemia, which could be due to severe internal pudendal arterial damage at initial injury. Excision of scar tissue has to be meticulous as it has been reported as a strong and independent factor of success, along with prostatic displacement [42]. Other reported characteristics associated with an increased risk of failure are angioembolization at the time of the original trauma and increased distraction defect length [43].

4. Associated sequelae

4.1. Erectile dysfunction (ED)

ED may be the consequence of different factors due to the pelvic fracture, which often are concomitant: nerve injury, vascular injury, and psychological impact. Regardless of associated urethral

injury, ED after pelvic fracture occurs in about 56% of patients [6]. Also, ED seems more severe after PFUI than pelvic fracture alone, not necessarily being a direct cause but rather a marker of severe pelvic injury and risk for neurovascular injury [47]. This has also been reflected in indicators of higher risk of ED development after PFUI: pubic symphysis diastasis, long urethral gap, lateral prostatic displacement [48].

Importantly, up to 20% of patients may recover some erectile function after delayed urethroplasty [6], likely reflecting recovery of neuropraxia. It is conjectured that this recovery may be even greater with the bulbar artery sparing technique [36]. In practice, it may be difficult to distinguish between erectile dysfunction due to the initial injury or due to a complication from the urethral surgery. For the most part, erectile dysfunction care is not specifically tailored to PFUI etiology. However, penile arterial revascularization might be considered when evaluation reveals an isolated arterial lesion affecting the internal pudendal or penile arteries that could potentially benefit from bypass surgery, typically using the inferior epigastric artery.

4.2. Urinary incontinence (UI)

UI after PFUI is rare and generally requires disruption of the function of both the external sphincter and the bladder neck. Causes can include sacral nerve injury, bladder neck injury, or external sphincter injury, possibly combined. Sacral nerve damage is reported in about 8% of PFUI [6], and may be responsible for an atonic bladder and patient need for intermittent catheterization. Such an injury could also lead to loss of constricting tone at the bladder neck. A bladder neck injury should be repaired at the time of initial trauma [49], and it seems that it is the injury the most associated with UI. The external sphincter may be dysfunctional after PFUI, but the reconsideration of the location of the disruption of the urethra at a bulbo-membranous location, more distal to the external sphincter, has led to discussions regarding the origins of UI after PFUI. Overall, UI after PFUI is reported in about 5% of cases [6], and about 10% after PFUI repair in large series [48]. In case of total disruption, it is impossible to distinguish the role on continence outcome of the PFUI surgical repair and the initial injury. Treatment of severe UI generally requires implantation of an artificial urinary sphincter because of unpredictable sling success in the face of prior urethroplasty and distorted pelvic bony anatomy. Detailed surgical planning needs to consider urethral anatomical considerations (e.g. corporal rerouting), the vascular status of the corpus spongiosum, and the status of the bladder neck. In the absence of BN injury, a bladder neck implantation may offer longer term erosion free survival of the device [49].

5. **Conclusion**

Long-term management of PFUI requires an exhaustive understanding of the acute urethral injury as well as damage to surrounding organs injuries to ensure successful outcomes. Optimal radiographic assessment combines retrograde and antegrade studies to fully delineate the distraction defect. Adjunctive use of MRI is helpful to define anatomy in complex cases. Delayed urethroplasty is the

treatment of choice, and is most often performed around 3 months post-injury. It consists in men of a bulbo-prostatic anastomotic urethroplasty which may requires several steps of increasing complexity to allow a tension-free anastomosis. Urethral patency is highly reliable by an elaborated perineal reconstructive approach. Evaluation of potential associated sequelae including ED or UI must be anticipated and taken into consideration in the surgical path to complete rehabilitation.

References:

1. Ali, M., Safriel, Y., Sclafani, S. J. A., & Schulze, R. (2003). CT signs of urethral injury. RadioGraphics, 23(5), 951–963. https://doi.org/10.1148/rg.234025097

2. Andrich, D. E., & Mundy, A. R. (2001). The nature of urethral injury in cases of pelvic fracture urethral trauma. The Journal of Urology, 165(5), 1492–1495. https://doi.org/10.1016/S0022-5347(05)66367-2

3. Balogh, Z., King, K. L., Mackay, P., McDougall, D., Mackenzie, S., Evans, J. A., et al. (2007). The epidemiology of pelvic ring fractures: A population-based study. Journal of Trauma, 63(5), 1066–1073. https://doi.org/10.1097/TA.0b013e3181589fa4

4. Barratt, R. C., Bernard, J., Mundy, A. R., & Greenwell, T. J. (2018). Pelvic fracture urethral injury in males — mechanisms of injury, management options and outcomes. Translational Andrology and Urology, 7(Suppl 1), S29–S30. https://doi.org/10.21037/tau.2017.12.35

5. Basta, A. M., Blackmore, C. C., & Wessells, H. (2007). Predicting urethral injury from pelvic fracture patterns in male patients with blunt trauma. The Journal of Urology, 177(2), 571–575. https://doi.org/10.1016/j.juro.2006.09.040

6. Chung, P. H., Gehring, C., Firoozabadi, R., & Voelzke, B. B. (2018). Risk stratification for erectile dysfunction after pelvic fracture urethral injuries. Urology, 115, 174–178. https://doi.org/10.1016/j.urology.2018.01.035

7. Cooperberg, M. R., McAninch, J. W., Alsikafi, N. F., & Elliott, S. P. (2007). Urethral reconstruction for traumatic posterior urethral disruption: Outcomes of a 25-year experience. The Journal of Urology, 178(6), 2006–2010. https://doi.org/10.1016/j.juro.2007.07.020

8. Demetriades, D., Karaiskakis, M., Toutouzas, K., Alo, K., Velmahos, G., & Chan, L. (2002). Pelvic fractures: Epidemiology and predictors of associated abdominal injuries and outcomes. The Journal of the American College of Surgeons, 195(1), 1–10. https://doi.org/10.1016/S1072-7515(02)01197-3

9. Dixon, C. M., Hricak, H., & McAninch, J. W. (1992). Magnetic resonance imaging of traumatic posterior urethral defects and pelvic crush injuries. The Journal of Urology, 148(4), 1162–1165. https://doi.org/10.1016/S0022-5347(17)36849-0

10. Elshout, P. J., Veskimae, E., MacLennan, S., Yuan, Y., Lumen, N., Gonsalves, M., et al. (2017). Outcomes of early endoscopic realignment versus suprapubic cystostomy and delayed urethroplasty for pelvic fracture-related posterior urethral injuries: A systematic review. European Urology Focus, 3(6), 545–553. https://doi.org/10.1016/j.euf.2017.03.001

11. Fendereski, K., McCormick, B. J., Keihani, S., Hagedorn, J. C., Voelzke, B., Selph, J. P., et al. (2022). The outcomes of pelvic fracture urethral injuries stratified by urethral injury severity: A prospective Multi-institutional

Genitourinary Trauma Study (MiGUTS). Urology, 170, 197–202. https://doi.org/10.1016/j.urology.2022.09.006

12. Figler, B. D., Dy, G., Wessells, H. B., & Voelzke, B. B. (2013). Long-term outcomes following posterior urethroplasty for traumatic pelvic-fracture associated posterior urethral disruption in a contemporary cohort. Journal of the American College of Surgeons, 217(Suppl), S149. https://doi.org/10.1016/j.jamcollsurg.2013.07.351

13. Fu, Q., Zhang, Y., Barbagli, G., Zhang, J., Xie, H., Sa, Y., et al. (2015). Factors that influence the outcome of open urethroplasty for pelvis fracture urethral defect (PFUD): An observational study from a single high-volume tertiary care center. World Journal of Urology, 33(11), 2169–2175. https://doi.org/10.1007/s00345-015-1533-4

14. Gelman, J. (2013). Tips for successful open surgical reconstruction of posterior urethral disruption injuries. Urologic Clinics of North America, 40(2), 381–392. https://doi.org/10.1016/j.ucl.2013.04.007

15. Giannoudis, P. V., Grotz, M. R. W., Tzioupis, C., Dinopoulos, H., Wells, G. E., Bouamra, O., et al. (2007). Prevalence of pelvic fractures, associated injuries, and mortality: The United Kingdom perspective. Journal of Trauma, 63(5), 875–883. https://doi.org/10.1097/01.ta.0000242259.67486.15

16. Gomez, R. G., & Scarberry, K. (2018). Anatomy and techniques in posterior urethroplasty. Translational Andrology and Urology, 7(6), 567–579. https://doi.org/10.21037/tau.2018.03.05

17. Horiguchi, A., Edo, H., Soga, S., Shinchi, M., Masunaga, A., Ito, K., et al. (2018). Pubourethral stump angle measured on preoperative magnetic resonance imaging predicts urethroplasty type for pelvic fracture urethral injury repair. Urology, 112, 198–204. https://doi.org/10.1016/j.urology.2017.09.038

18. Horiguchi, A., Edo, H., Shinchi, M., Ojima, K., Hirano, Y., Ito, K., et al. (2022). Membranous urethral length on magnetic resonance imaging as a novel predictor of urinary continence after delayed anastomotic urethroplasty for pelvic fracture urethral injury. World Journal of Urology, 40(1), 147–153. https://doi.org/10.1007/s00345-021-03840-0

19. Horiguchi, A., Masunaga, A., Shinchi, M., Ito, K., Asano, T., & Azuma, R. (2018). Do transurethral treatments increase the complexity of urethral strictures? The Journal of Urology, 199(2), 508–514. https://doi.org/10.1016/j.juro.2017.08.100

20. Horiguchi, A., Ojima, K., Shinchi, M., Hirano, Y., Hamamoto, K., Ito, K., et al. (2020). Usefulness of a high-speed surgical air drill in pubectomy during delayed anastomotic urethroplasty for pelvic fracture urethral injury. International Journal of Urology, 27(9), 1002–1007. https://doi.org/10.1111/iju.14344

21. Joshi, P. M., Batra, V., & Kulkarni, S. B. (2019). Controversies in the management of pelvic fracture urethral distraction defects. Turkish Journal of Urology, 45(1), 1–6. https://doi.org/10.5152/tud.2018.57699

22. Joshi, P. M., Desai, D. J., Shah, D., Joshi, D., & Kulkarni, S. B. (2017). Injury in pelvic fracture urethral injury is membranobulbar: Fact or myth. Urology, 102, e9–e10. https://doi.org/10.1016/j.urology.2017.01.004

23. Joshi, P. M., & Kulkarni, S. B. (2020). Management of urethral injuries associated with complex pelvic fracture. In F. E. Martins, S. B. Kulkarni, & T. S. Köhler (Eds.), Textbook of male genitourethral reconstruction (pp. 267–278). Springer International Publishing. https://doi.org/10.1007/978-3-030-21447-0_22

24. Kamel, M. I., & Koraitim, M. M. (2015). Perineal repair of pelvic fracture urethral injury: In pursuit of a successful outcome. BJU International, 116(2), 265–270. https://doi.org/10.1111/bju.12679

25. Keihani, S., McCormick, B. J., Hagedorn, J., Selph, J. P., Figler, B. D., Johnsen, N. V., et al. (2023). A multicenter prospective cohort study of endoscopic urethral realignment versus suprapubic cystostomy after complete pelvic fracture urethral injury. Journal of Trauma and Acute Care Surgery, 94(3), 344–349. https://doi.org/10.1097/TA.0000000000003774

26. Khurana, C. S., Kushwaha, S. S., Dorairajan, L. N., & Kalra, S. (2023). Primary management of pelvic fracture urethral injury in a woman: Challenges and outcome. BMJ Case Reports, 16, e253852. https://doi.org/10.1136/bcr-2022-253852

27. Koraitim, M. M. (2009). Predictors of surgical approach to repair pelvic fracture urethral distraction defects. The Journal of Urology, 182(4), 1435–1439. https://doi.org/10.1016/j.juro.2009.06.022

28. Koraitim, M. M. (2013). Predictors of erectile dysfunction post pelvic fracture urethral injuries: A multivariate analysis. Urology, 81(5), 1081–1085. https://doi.org/10.1016/j.urology.2012.12.040

29. Koraitim, M. M. (2015). Optimising the outcome after anastomotic posterior urethroplasty. Arab Journal of Urology, 13(1), 27–31. https://doi.org/10.1016/j.aju.2014.12.006

30. Koraitim, M. M., Marzouk, M. E., Atta, M. A., & Orabi, S. S. (1996). Risk factors and mechanism of urethral injury in pelvic fractures. British Journal of Urology, 77(6), 876–880. https://doi.org/10.1046/j.1464-410x.1996.01119.x

31. Kulkarni, S. B., Barbagli, G., Kulkarni, J. S., Romano, G., & Lazzeri, M. (2010). Posterior urethral stricture after pelvic fracture urethral distraction defects in developing and developed countries, and choice of surgical technique. The Journal of Urology, 183(4), 1049–1054. https://doi.org/10.1016/j.juro.2009.11.045

32. Kulkarni, S. B., Orabi, H., Kavanagh, A., & Joshi, P. M. (2020). RE Re Do urethroplasty after multiple failed surgeries of pelvic fracture urethral injury. World Journal of Urology, 38(11), 3019–3025. https://doi.org/10.1007/s00345-019-02917-1

33. Lin, J. S., Skokan, A. J., Wessells, H., & Hagedorn, J. C. (2023). Management of male stress urinary incontinence in high-risk patients: A narrative review. Translational Andrology and Urology, 12(6), 898–917. https://doi.org/10.21037/tau-22-727

34. Lüthje, P., Nurmi, I., Kataja, M., Heliövaara, M., & Santavirta, S. (1995). Incidence of pelvic fractures in Finland in 1988. Acta Orthopaedica Scandinavica, 66(3), 245–248. https://doi.org/10.3109/17453679508995533

35. Martínez-Piñeiro, L., Djakovic, N., Plas, E., Mor, Y., Santucci, R. A., Serafetinidis, E., et al. (2010). EAU Guidelines on urethral trauma. European Urology, 57(5), 791–803. https://doi.org/10.1016/j.eururo.2010.01.013

36. Martínez-Piñeiro, L., Djakovic, N., Plas, E., Mor, Y., Santucci, R. A., Serafetinidis, E., et al. (2010). EAU guidelines on urethral trauma. European Urology, 57(5), 791–803. https://doi.org/10.1016/j.eururo.2010.01.013

37. Mayher, B. E., Guyton, J. L., & Gingrich, J. R. (2001). Impact of urethral injury management on the treatment and outcome of concurrent pelvic fractures. Urology, 57(4), 439–442. https://doi.org/10.1016/S0090-4295(00)01038-4

38. McCormick, B. J., Keihani, S., Hagedorn, J., Selph, J. P., Figler, B. D., Johnsen, N. V., et al. (2023). A multicenter prospective cohort study of endoscopic urethral realignment versus suprapubic cystostomy after complete pelvic fracture urethral injury. Journal of Trauma and Acute Care Surgery, 94(3), 344–349. https://doi.org/10.1097/TA.0000000000003774

39. Moore, E. E., Cogbill, T. H., Jurkovich, G. J., McAninch, J. W., Champion, H. R., Gennarelli, T. A., et al. (1992). Organ injury scaling. III: Chest wall, abdominal vascular, ureter, bladder, and urethra. Journal of Trauma, 33(3), 337–339. https://doi.org/10.1097/00005373-199209000-00011

40. Mouraviev, V. B., & Santucci, R. A. (2005). Cadaveric anatomy of pelvic fracture urethral distraction injury: Most injuries are distal to the external urinary sphincter. The Journal of Urology, 173(3), 869–872. https://doi.org/10.1097/01.ju.0000152252.48176.69

41. Patel, D. N., Fok, C. S., Webster, G. D., & Anger, J. T. (2017). Female urethral injuries associated with pelvic fracture: A systematic review of the literature. BJU International, 120(6), 766–773. https://doi.org/10.1111/bju.13989

42. Podestá, M. L., & Jordan, G. H. (2001). Pelvic fracture urethral injuries in girls. The Journal of Urology, 165(5), 1660–1665. https://doi.org/10.1097/00005347-200105000-00021

43. Scarberry, K., Bonomo, J., & Gómez, R. G. (2018). Delayed posterior urethroplasty following pelvic fracture urethral injury: Do we have to wait 3 months? Urology, 116, 193–197. https://doi.org/10.1016/j.urology.2018.01.018

44. Silva Gaspar, S. R. da, Ferreira, N. D., Oliveira, T., Oliveira, P., Dias, J. S., & Lopes, T. M. (2017). Magnetic resonance imaging and pelvic fracture urethral injuries. Urology, 110, 9–15. https://doi.org/10.1016/j.urology.2017.06.041

45. Sreeranga, Y. L., Joshi, P. M., Bandini, M., & Kulkarni, S. B. (2022). Comprehensive analysis of paediatric pelvic fracture urethral injury: A reconstructive centre experience. BJU International, 130(1), 114–125. https://doi.org/10.1111/bju.15686

46. Turner-Warwick, R. (1977). Complex traumatic posterior urethral strictures. The Journal of Urology, 118(4), 564–574. https://doi.org/10.1016/S0022-5347(17)58109-4

47. Webster, G. D., & Sihelnik, S. (1985). The management of strictures of the membranous urethra. The Journal of Urology, 134(3), 469–473. https://doi.org/10.1016/S0022-5347(17)47243-0

48. Wessells, H., Morey, A., Souter, L., Rahimi, L., & Vanni, A. (2023). Urethral Stricture Disease Guideline Amendment (2023). The Journal of Urology, 210(1), 64–71. https://doi.org/10.1097/JU.0000000000003482

49. Yepes, C., Oszczudlowski, M., Bandini, M., Joshi, P. M., Alrefaey, A., Bhadranavar, S., et al. (2023). Management of pelvic fracture urethral injury: Is supracrural urethral rerouting (step 4) becoming anecdotical or does it remain in force? Journal of Clinical Medicine, 12(6), 2427. https://doi.org/10.3390/jcm12062427